helios Technology Challenge

Hardware Engineering Launchpad Inspired by Open Source

HTC-01 Cost-Effective Additive Manufacturing in Space

HELIOS Technology Challenge Guide

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Hardware Engineering Launchpad Inspired by Open Source

HTC-01: Cost-effective Additive Manufacturing in Space
HELIOS Technology Challenge Guide

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National Aeronautics and Space Administration

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HTC-01: Cost-effective Additive Manufacturing in Space
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1.0 HELIOS Technology Challenge Guide

Welcome to the HELIOS Technology Challenge Guide. This document is intended to serve as a general road map for participants of the **HELIOS Technology Challenge [HTC] Program** and the associated inaugural challenge: **HTC-01: Cost-Effective Additive Manufacturing in Space**. Please note that this guide is not a rule book and is not meant to hinder the development of innovative ideas. Its primary goal is to highlight the objectives of the HTC-01 Challenge and to describe possible solution routes and pitfalls that such technology may encounter in space. Please also note that participants wishing to demonstrate any hardware developed under this program during any future HELIOS Technology Challenge "showcase" event(s) may be subject to event regulations to be published separately at a later date.

1.1 HELIOS Technology Challenge Program Introduction

As NASA renews its commitment to deep space exploration, new ways must be sought out to make the process of developing required technologies more cost-effective. Recognizing the valuable problem solving potential that exists in the American public, the HELIOS Technology Challenge Pilot Program was proposed in 2012 as an experiment in collaboration. **HELIOS** stands for **Hardware Engineering Launchpad Inspired by Open Source**. The principal goal of this low-cost, no-frills project is to promote cost-effective innovation and collaboration with the public in the development of open source-friendly, early stage concept-type technology. HELIOS is not a multi-million dollar project but rather an ultra-low cost experiment in open source hardware engineering with a specific audience in mind. The program establishes a virtual pathway that enables NASA "Challenge Champions" to collaborate with Hackerspace and Makerspace communities in the solving of space technology related problems.

The HELIOS Technology Challenge Pilot Program is based on three core principles: cost-effective innovation, a collaborative work environment and open source-based idea ownership. HELIOS is not about fancy and exotic solutions. It's about developing simple, low-cost ideas that get the job done. A great example of this is our recent HELIOS Technology Challenge Vodcast Series: No elaborate productions here, just five colleagues, a video camera, a microphone and passion for space technology. It may not be pretty, but that's the idea — getting the job done at a low cost by means of innovative partnership based solution approach.

Collaboration is another very important core principle. While traditional competitive programs yield a single winner, a collaborative effort approach results in all participants benefiting from the resulting product or solution. Participants should understand that if they are looking to patent their ideas and "make a million bucks," then the HELIOS Program is not for them. There are a number of other programs that facilitate and or promote the competitive approach. More information on other NASA programs can be found at nasa.gov. The HELIOS Program centers around the concept that the merging of ideas of many contributors can result in solutions greater than what any one member can develop on their own. That said, the HELIOS Technology Challenge Program is more appropriate for participants seeking a collaborative pathway toward innovation. Future HELIOS Technology Challenge events may, for example, reward top collaborators as opposed to top competitors. Since the HELIOS Program revolves around nation-wide collaboration, the idea of open-source hardware engineering is also an essential part of the problem solving process. Participants should understand and acknowledge that the intent is to share ideas that will benefit everyone. There are multiple online resources that describe the process and concept of open-source development. Participants are encouraged to fully understand this style of collaboration prior to engaging in this endeavor.

1.2 HELIOS Technology Challenge Overview

One of the many challenges with long duration spaceflight, including maintaining operations aboard a space station, revolves around the logistic difficulties that arise with launching and storing goods in space. Launching goods into space is very expensive, so ways of reducing the need to launch less-than-absolutely-necessary items is a value-added pursuit. For any manned space flight mission, having spare parts is essential; however, these can take up valuable storage space and can be costly to launch. Additionally, since it may be difficult to predict what will break in space, a conservative mission manifest may require numerous spares. For these reasons, the ability to repair and or replace a broken part without having to launch a spare one is highly attractive. Additive manufacturing techniques such as rapid prototyping could perhaps enable future astronauts to print out replacement components in future missions.
Another key challenge with long duration spaceflight is the disposal of in-space consumables and broken components. Trash cannot simply be disposed overboard from a spacecraft. Trash could potentially become hazardous debris that could endanger astronauts, spacecraft and satellites, not to mention the concept of in-space pollution. Trash is generally stored until a return vehicle can bring it back to earth or is slated to be burned up aboard a disposable vehicle upon atmospheric re-entry. Recycling in space is an attractive concept because it would reduce the amount of trash stored.

The inaugural HELIOS Technology Challenge is titled ***HTC-01: Cost-Effective Additive Manufacturing in Space*** and has three major objectives that explore technology gaps associated with the above mentioned concepts, recycling and rapid prototyping in space. These objectives of the HTC-01 Challenge are: the development of cost-effective and innovative ways of recycling in-space consumables, such as astronaut food packaging, into 3D printing media;

the solving of particular hardware design challenges associated with performing rapid prototyping in a micro-gravity environment; and the development of in-space applications for additive manufacturing in space.

2.0 HELIOS Technology Challenge Guidelines

As mentioned, the 2012 Helios Tech Challenge: **HTC-01: Cost-effective Additive Manufacturing in Space** is divided into three key parts: the process of generating printable media, developing and advancing the printing hardware technology, and developing applications based on the resulting hardware and recycled media. The challenge is summarized in Fig. 1 below. Within each key topic, a number of technology focus areas that will require solutions in the future are suggested. Participants of the challenge are invited to participate and contribute to one or more areas. The only rule to keep in mind is that this is collaborative approach at problem solving and all work and data should be treated and considered open source.

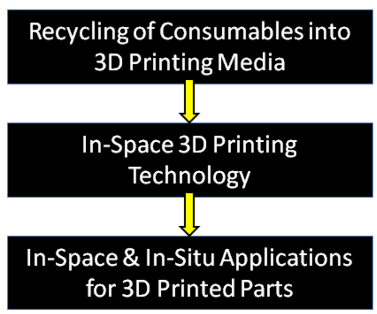

FIGURE 1. HTC-01: COST-EFFECTIVE ADDITIVE MANUFACTURING IN SPACE

2.1 Recycling of In-Space Consumables into 3-D Printer Media

Recycling in space is a very attractive concept because of the high costs associated with launching goods into space. When this idea is coupled with the concept of converting trash generated in space for the purpose of producing raw 3D printing media, the need to launch and store spare parts could be reduced. Space garbage resulting from consumables, such as food packaging, is an attractive medium to explore because there is plenty of it and it has the potential to be processed in this manner. Many consumable products are required to support manned space flight including food packaging, filters and even astronaut clothing. Several of these disposable-type goods have great recycling potential since they meet three key criteria. First, in order for a consumable to be a practical source of recyclable material, it should be available in large quantities. In order for a process such as rapid prototyping in space to be cost-effective, the amount of parts over time that could potentially be printed needs to exceed the mass of the machine that is performing the recycling process as well as the media used. If not, it would just be more cost-effective to carry spares. Second, any process developed should have a reasonable demand on energy input. In essence, if the process consumes an excessive amount of time and available energy, then it may not be practical for use in space. Third, application is also important. If there is no use for a certain recycled material then the production of such material may not be a practical process to be used as well. There are perhaps many other criteria that may be considered; however, the characteristics mentioned constitute a good starting point for the technology maturity involved in this challenge.

The objectives of this component of the challenge are as follows:

- **Develop a process and/or device for recycling astronaut food packages and/or other in-space consumables into a 3-D printable material. Attractive solutions will take into consideration safety, out-gassing and/or particulate mitigation, micro-gravity practicality, energy consumed and/or released by the system, byproducts produced from the process, and system complexity, among others.**

- **As an alternate approach, develop and/or suggest a 3-D printable material that can be used for storing astronaut food consumables.**

Researching and understanding the materials and properties of what astronaut consumables are made of will be vital to this challenge. The recycled printing media can be made from, but is not limited to, materials currently available on the International Space Station (ISS) or heritage vehicles such as the space shuttle. Please see Section 2.1.1 "In-space Consumables" for more details.

Material Safety Data Sheet (MSDS) sheets links are provided in Section 2.1.3 for NASA consumables. Participants of the HELIOS Technology Challenge are not required to utilize these specific materials, but if they do, they must be aware of the precautions listed in their respective MSDS sheets. NASA and the HELIOS Technology Challenge are not responsible for participants who do not follow the proper advisement when handling these materials. Exploring the recommended in-space packaging is suggested, but no limitations are hereby placed on the participants from proposing new packaging materials that could also double as potential 3-D printing media as well. NASA is not responsible for participants not following the proper documentation of handling materials. Hardware development is dangerous in nature and requires proper personal protection equipment (PPE). Please follow all material recommended guidelines in the respective MSDS sheets and product data. NASA or HELIOS Technology Challenge will not provide PPE or consumable materials.

For participants wishing to explore alternate new materials, please note the following considerations. All current NASA space foods are stored under ambient storage conditions and safely maintain a shelf life of nine months to five years. Space shuttle foods are required to have a minimum shelf life of nine months. International Space Station foods require a one-year shelf life. All rehydratable and bite-sized foods destined for ISS are overwrapped with an aluminum foil laminate and vacuum-sealed to improve barrier properties, increasing shelf life. The food system for planetary outposts will require five-year shelf life because of planned mission lengths. The shelf life of proposed new potential packaging materials does not have to be established. Most importantly, for the HELIOS Technology Challenge, participants must demonstrate the ability to convert any new material proposed into recyclable 3-D printing media.

As a final note, there are other typical components that often fail aboard the ISS including laptop screens, hard drives, lighting systems, light-emitting diodes (LEDs) and multi-purpose brackets (e.g. Bogan arms) among other parts. Participants are also invited to explore these items for possible repurposing. Future information may be published in the form of technical bulletins.

2.1.1 In-space Food Packaging

The following section provides, as reference, details of various food packaging materials that have been used or are currently in use in space. Participants are invited to explore these materials but are welcomed to use close substitutes.

Retort Pouch

This pouch is used for thermo-stabilized and irradiated foods that are normally commercial pouches. It has been modeled using Department of Defense specifications for the Meals Ready to Eat program.

Materials (Typical)	• Polyethylene Terephthalate (PET) • Biaxially Orientated • Nylon (BiaxNylon) • Aluminum Foil (Al Foil) • Cast Polypropylene (CPP)	
Dimensions	• Length x Width (in.): 8.125 x 4.75 • Thickness (in): 0.0048	

FIGURE 2. RETORT POUCH

Commercial Packaging

A small amount of commercial plastic pudding containers, commercial full-panel pullout aluminum cans and single-serving commercial condiment pouches were used on the space shuttle and are currently being used on the ISS.

Materials (Typical)	• Polyamide (PA-“Nylon”) • Ethylene Vinyl Alcohol (EVOH) • Polyethylene (PE)	
Dimensions	• Vary	

FIGURE 3. COMMERCIAL PACKAGING

Bite-Size Pouch

NASA uses Combitherm Paxx packaging material for its rehydratable and bite-sized packages.

Materials (Typical)	• Polyamide (PA-"Nylon") • Ethylene Vinyl Alcohol (EVOH) • Polyethylene (PE)	
Dimensions	• Length x Width (in.) 7.5 x 3.563 • Thickness (in.): 0.0045	

FIGURE 4. BITE SIZE POUCH

Beverage Pouch w/ Septum Adapter Assembly

The beverage package is a modified beverage package made from a foil laminate. A septum installed in a septum adapter allows water to be injected into the beverage and rehydratable package.

Materials (Typical)	• Polyethylene Terephthalate (PET) • Aluminum Foil(Al Foil) • Linear Low Density Polyethylene + Low Density Polyethylene (LLDPE+LDPE)	
Dimensions	• Length x Width (in.) 8.8 x 3.84 • Thickness (in.): 0.00498	

FIGURE 5. BEVERAGE POUCH W/ SEPTUM ADAPTER ASSEMBLY

Rehydratable Pouch w/ Septum Adapter Assembly

This packaging allows food to retain moisture when water is added. It is procured from the vendor in the shape of a cup and a lid and is made of flexible material to aid in trash compression.

Materials (Typical)	• Polyamide (PA-"nylon") Ethylene Vinyl Alcohol (EVOH) • Polyethylene (PE)	
Dimensions	• Length x Width (in.): 6.0 x 5.0 • Thickness (in.): .0045/0.0090/variable	

FIGURE 6. REHYDRATABLE POUCH W/ SEPTUM ADAPTER ASSEMBLY

Septum Adapter Assembly

The septum adapter is an injected molded device for holding the septum. The septum adapter is inserted, flushed three times with nitrogen, and is sealed into the package during closure. The septum adapter is molded from Low Density Polyethylene (LDPE) and provides an entry for the needle used to inject water and then seals off when the needle is withdrawn. The septum is molded from silicon rubber and provides an entry for the needle to inject water and then seals off when the needle is withdrawn. The patch is a foil laminate is pierced by the galley needle when rehydration takes place.

Materials (Typical)	• Low Density Polyethylene (LDPE) • Silicone • Polyethylene Terephthalate (PET)	
Dimensions	• Vary	

FIGURE 7. SEPTUM ADAPTER ASSEMBLY

Large Overwrap		
Materials (Typical)	• Polyethylene Terephthalate (PET) • Low Density Polyethylene White (White-LDPE) • Aluminum Foil (Al Foil) • Surlyn	**<u>Image not Available</u>**
Dimensions	• Length x Width (in): 8.12 x 6.50 • Thickness (in.): 0.00368	

FIGURE 8. LARGE OVERWRAP

Small Overwrap		
Materials (Typical)	• Polyethylene Terephthalate (PET) • Low Density Polyethylene White (White-LDPE) • Aluminum Foil (Al Foil) • Surlyn	**<u>Image not Available</u>**
Dimensions	• Length x Width (in): 7.25 x 4.75 • Thickness (in.): 0.00368	

FIGURE 9. SMALL OVERWRAP

2.1.2 Food Packaging Material Index

- PET – Polyethylene Terephthalate
- CPP – Cast Polypropylene
- PE – Polyethylene
- LDPE - Low Density Polyethylene
- LLDPE – Linear Low Density Polyethylene
- PA – Polyamide (Nylon)
- EVOH – Ethylene Vinyl Alcohol
- Biax – Biaxially Oriented
- Al – Aluminum
- SAA – Septum Adapter Assembly

2.1.3 Material Safety Data Sheets

The Material Safety and Data Sheets (MSDS) for each of the astronaut consumables listed in section 2.1.1 "The Consumables Available" can be found at the links below. NASA and HELIOS Technology Challenge are not responsible for the content located at these links. Links referenced could be potentially broken, or outdated.

Product	Material	MSDS Links
Retort Pouch	PET	http://www.plasticsmadesimple.com/DataSheets/PET_MSDS.pdf
	BiaxNylon	http://www.chemcas.com/msds_archive/part2/cas/gg_msds/biaxispackaging_com---MSDS.asp
	Al Foil	http://www.sciencelab.com/msds.php?msdsId=9922844
	CPP	http://www.poulengerusa.com/DragonfireCpp/DragonfireCPP_msds.htm
Bitesize Pouch	PA	http://www.plasticsmadesimple.com/DataSheets/Nylon_MSDS.pdf
	EVOH	http://www.soarnol.com/eng/msds/pdf/usa.pdf
	PE	http://www.arkema-inc.com/plants/canada/msds/AP-P101.pdf
Beverage Pouch	PET	http://www.plasticsmadesimple.com/DataSheets/PET_MSDS.pdf
	AlFoil	http://www.sciencelab.com/msds.php?msdsId=9922844
	LLDPE+LDPE	http://logisticsmatters.info/MSDS/POLYETHYLENE_LDPE_LLDPE_PE01_%20Dec%2006.pdf
Rehydratable Pouch	PA	http://www.plasticsmadesimple.com/DataSheets/Nylon_MSDS.pdf
	EVOH	http://www.soarnol.com/eng/msds/pdf/usa.pdf
	PE	http://www.arkema-inc.com/plants/canada/msds/AP-P101.pdf
Septum Adapter	LDPE	http://logisticsmatters.info/MSDS/POLYETHYLENE_LDPE_LLDPE_PE01_%20Dec%2006.pdf
Septum	Silicone	http://www.sciencelab.com/msds.php?msdsId=9924921
Patch	PET	http://www.plasticsmadesimple.com/DataSheets/PET_MSDS.pdf
	Al Foil	http://www.sciencelab.com/msds.php?msdsId=9922844
	LLDPE+LDPE	http://logisticsmatters.info/MSDS/POLYETHYLENE_LDPE_LLDPE_PE01_%20Dec%2006.pdf
Large Overwrap	PET	http://www.plasticsmadesimple.com/DataSheets/PET_MSDS.pdf
	White-LDPE	http://logisticsmatters.info/MSDS/POLYETHYLENE_LDPE_LLDPE_PE01_%20Dec%2006.pdf
	Al Foil	http://www.sciencelab.com/msds.php?msdsId=9922844
	Surlyn	http://msds.dupont.com/msds/pdfs/EN/PEN_09004a2f8000633e.pdf
Small Overwrap	PET	http://www.plasticsmadesimple.com/DataSheets/PET_MSDS.pdf
	White-LDPE	http://logisticsmatters.info/MSDS/POLYETHYLENE_LDPE_LLDPE_PE01_%20Dec%2006.pdf
	Al Foil	http://www.sciencelab.com/msds.php?msdsId=9922844
	Surlyn	http://msds.dupont.com/msds/pdfs/EN/PEN_09004a2f8000633e.pdf

FIGURE 10. FOOD PACKAGING MATERIAL MSDS LINKS

2.2 In-Space 3-D Printing Technology

While many advances have been made in 3-D printing in the last few years, there are a number of challenges that will have to be overcome prior to making this a viable technology for routine operations in space. Today's 3-D printing technology falls short of getting on board a deep space mission and much development and research is still needed. Current 3-D printing media is very heavy and takes up a lot of space, in addition to being expensive, all of which keep this amazing technology grounded here on Earth. Many 3-D printing techniques have processes and/or hardware that may be sensitive and or require gravity for proper operation. Developing printing techniques that are insensitive to a micro-gravity environment are therefore essential for their use in space. Additionally, size and mass of the hardware involved and the media it uses are equally essential. There is limited space aboard a typical space station, spacecraft and/or launch vehicle. Developing new, innovative ways to repackage existing hardware is crucial in order to push 3-D printing technology to flight-ready hardware in the future. The objective of the second component of the challenge is therefore to:

- **Develop and/or modify an existing open source 3-D printer that addresses one or more of the technical challenges that this additive manufacturing technique will encounter in space including, but not limited to: 3-D printer packaging, printing in a micro-gravity environment, out-gassing mitigation, and integration of the device with ISS equipment and launch containers among others.**

The expectation is that hardware solutions initiated through the HELIOS Launchpad will address technical problems that have a low Technology Readiness Level [TRL]. Solutions do not initially need to address all of the considerations listed; moreover, this is the reason for a collaborative approach to problem solving. The HELIOS Program hopes that many different solutions will eventually merge to address all of the required challenge components.

While there are many different types of additive manufacturing and 3-D printing processes, some are perhaps better suited than others for in-space applications. In-space use adds constraints that are not normally problematic on earth. For example, particulate generation involved and or resulting from a given process is harder to deal with in space due to the need for more complex filtration systems; therefore, printing techniques that utilize powder-based and/or liquid-based media may present a higher degree of complexity rendering such techniques less practical for in-space use. Processes such as Fused Filament Fabrication (FFF) that utilize a solid filament as printing media are perhaps more attractive paths to consider first; hardware based on this method is relatively less complex than other more exotic methods and may be a cost-effective solution; however, disposition of generated fumes is an important byproduct that needs to be addressed. More considerations will be published as needed in future bulletins.

NASA is not responsible for participants not following the proper documentation for handling materials and/or off-the shelf components. Hardware development is dangerous in nature and safety practices should be exercised at all times including the use of appropriate Personal Protection Equipment (PPE). Please follow all material recommended guidelines in the respective MSDS sheets and product data.

Strategies, developments and designs developed under this program should be created with the understanding that the resulting information will be shared as open-source and will be available to the general public during and after the completion of the HELIOS Technology Challenge. Open-source technology development promotes free redistribution and access to an end product's design and implementation details.

2.2.1 Potential Payload Volumes

Participants may wish to focus on the packaging and/or mass reduction of printing and or recycling hardware aspects of the challenge. For this specific task, two possible volumes are given as target maximum dimensions for the hardware. These are only recommended specifications. It is not required for participants focusing on other aspects of this challenge to build solutions around these volumes.

Figure 11 illustrates a space station EXPRESS Rack that has a standard storage drawer for support equipment of EXPRESS-type operations such as flex lines for vacuum and fluid, and special tools. Services such as electrical hook-ups, ventilation, and nitrogen hook-ups, are provided in the back of each rack for each locker location. This volume could be considered a good place to start for defining a maximum volume for a low cost 3D printer. Theoretically, the volume could be doubled and or quadrupled to fit larger printing equipment provided a new housing is designed. More information regarding this rack will be available through future technical bulletins. Additionally, Figure 12 illustrates another standard drawer with the potential to store support hardware. This volume could be used to house support equipment, printing media or tools.

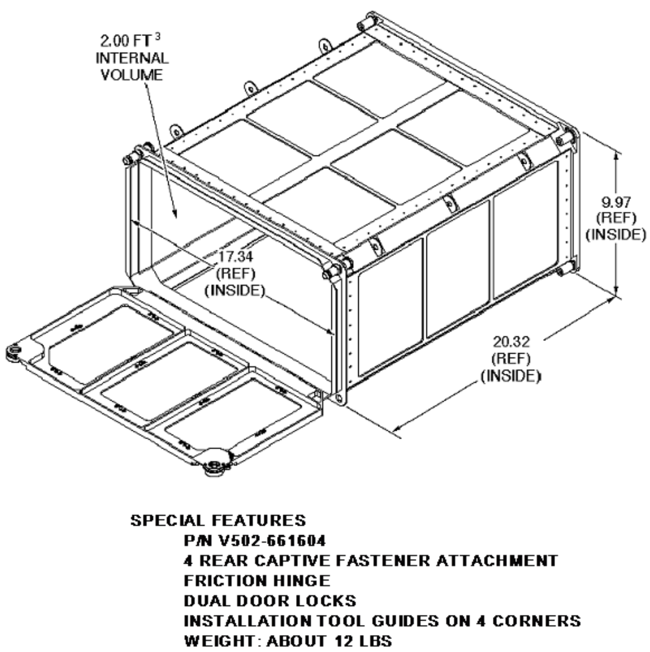

FIGURE 11. POTENTIAL PAYLOAD VOLUMES

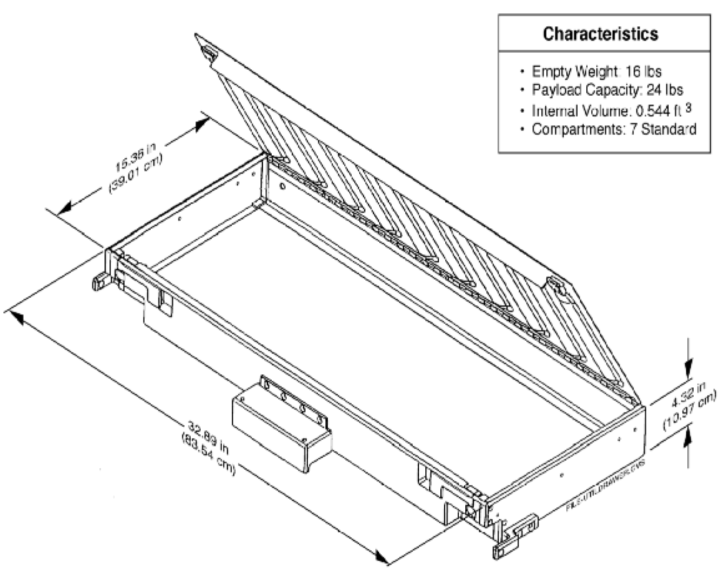

FIGURE 12. POTENTIAL PAYLOAD VOLUMES II

Figure 13 below, provides additional reference information on the services available for the International Space Station [ISS] Mid Level Locker [MDL] and the International Subrack Interface Standard [ISIS] racks. Participants selecting to explore the hardware integration aspects of the challenge may use the listed specifications as a guide for hardware development.

Resource	Amount per Payload Position	
	MDL	ISIS Drawer
Structural Attachment	• Attachment to Rack per Middeck-IDD • 72 lb@ +10in cg	• Attachment to Rack per ISIS Spec • 64 lb within cg constraints
Power	• 5,10,15, or 20 Amp at 28 VDC	• 5,10,15, or 20 Amp at 28 VDC
Thermal Control / Air	• Nominal less than 200W (1200W rack maximum & 500W cabin heal load)	• Nominal less than 100W
Water	• 45.5 kg/hr (100 lbs/hr) • 500 Watts Heat Rejection	• Water cooling not available
Data	• 1-RS-422 • 1-Ethernet • 2-Analog • 3-Discrete (bi-directional)	• 1-RS-422 • 1-Ethernet • 1-Analog • 2-Discrete (bi-directional)
Video	• NTSC/RC 170A feed from payload source (Shared)	• NTSC/RC 170A feed from payload source (Shared)
Venting	• Evacuate payload container down to 0.001 torr from 40 psia maximum	• Evacuate payload container down to 0.001 torr from 40 psia maximum
Nitrogen	• 0.23 kg/min (0.5 lb/min) • Max. @ 80-120 psi (one/rack)	• 0.23 kg/min (0.5 lb/min) • Max. @ 80-120 psi (one/rack)

FIGURE 13. PAYLOAD RESOURCES*

*__NASA MSFC Mission Operations Laboratory (MOL) Payload Resources/EO20__ courtesy of: Tony Cox, NASA; Content from “Express Rack Overview” Presentation dated March 23, 2012.

2.2.2 Other Technology Considerations

As mentioned, one of the goals of this challenge is to develop in-space 3-D printing capabilities, processes, and technologies that could be implemented in a deep space, and in a micro-gravity-friendly environment. Because of this, it is recommended that the any developed 3-D printing hardware take into consideration as best as possible the mentioned constraints. Although ideas are not hereby restricted, use of the following technologies and components are not recommended for space applications:

- Unsealed fan-cooled motors and controllers
- Sensors that rely on the earth's magnetic field
- Ultrasonic or other sound-based sensors
- Earth-based or earth orbit-based radio aids (e.g. GPS, VOR, cell phone)
- Use of fundamental physical processes, gases, fluids, or consumables that would not work in such environments.

Please note that for any future HELIOS Technology Challenge events that may include hardware demonstration by participants may require the said hardware to adhere to event safety regulations. Such regulations will be published in a separate document.

2.3 In-Space & In-Situ Applications for 3-D Printed Parts

The final component of the challenge addresses possible applications of the developed processes and hardware. Certain parts may be more suitable to be manufactured using a 3-D printing process than others. Keeping in mind the limitations that this form of additive manufacturing may have, what could be built using recycled media that could be useful in space or in a lunar or Martian colony? NASA wants innovative ideas and new technology development, so there is no limit to the creativity for various potential application solutions. The objective of the last component of the 2012 HELIOS Technology Challenge addresses this question and it is stated as follows:

> ➢ **Develop concepts for useful articles that could be generated using the recycled 3-D printing media and low-cost printing hardware developed in the previous two challenge components.**

3.0 The HELIOS Technology Challenge Program Participation

3.1 Eligibility

While the HELIOS Technology Challenge targets Hackerspaces, Makerspaces, citizen inventors and DIY-ers, the program is open to the general public. Individuals need not be members of a local Hackerspace. Participants, individuals and teams are encouraged to register online at www.helioschallenge.org. Registration will allow participants to take full-advantage of the online collaboration environment including receiving updates, change notifications, and other information. Registration will also enable the tracking of the collaborative effort. Given that this program is based on open source and collaboration, a traditional competition-based incentive model is not applicable; consequently the HELIOS Technology Challenge Program will attempt to reward the collaborative and innovative effort instead.

3.2 The HELIOS Launchpad

The site www.helioschallenge.org was established to help promote the collaborative effort. It features a forum and a wiki style page for participants to use. It is meant to house questions, comments, and solutions regarding the concepts described in this document. Participants can post as many solutions as they want and will not be limited to the amount of collaboration they participate in; however, HELIOS Technology Challenge officials will be monitoring all posts. All posts will be subject to removal at any time officials if they are deemed unfit for online publishing in any way. Posts can be in the form of pictures, video, links, text, etc. We encourage all participants to post as much valuable and pertinent content as possible in regards to the HELIOS Technology Challenge.

4.0 HELIOS Technology Challenge Event

The pilot HELIOS Tech Challenge Pilot Program will run from 2012-2013 and will culminate with an event that will showcase the hardware and ideas produced by the platform. The event will bring Hackerspaces and NASA together to evaluate and discuss potential solutions. As mentioned previously, the HELIOS Technology Challenge Program is a pilot program designed to evaluate the possibility of establishing a long term relationship between NASA, Hackerspaces and Makerspaces. The event mentioned is currently being planned and more details will follow. Please note that, since the HELIOS Program is designed to be more of a collaborative effort, any competitive elements of traditional challenge competition will operate differently. Unlike a traditional competition where a winner is selected, recognition will be provided to top and/or most innovative collaborators.

Please visit our "Future Event" thread for planning details. Leave comments on what you would like the showcase and networking event to look like. A future document with the HELIOS Technology Challenge event details will be released containing any necessary event regulations. Please register on www.helioschallenge.org to receive any updates.

5.0 Frequently Asked Questions (FAQ)

Questions, answers, and additional competition information will be provided on www.helioschallenge.org.

Who can participate?
While the HELIOS Technology Challenge Program targets Hackerspaces, Makerspaces, citizen inventors and DIY-ers, the program is open to the general public. Both individuals and teams are welcomed.

Is the HELIOS Technology Challenge a competition?
No. The HELIOS Technology Challenge is a collaborative, open-source-friendly, effort hosted by NASA; however, future events may seek to reward top collaborators and innovators. In other words, any potential award recipients may include individuals or teams that contribute and share the most on the challenge site.

Are there volumetric limitations to the hardware?
In general, no; however, a very specific part of the challenge focusing on printer packaging does have suggested maximum dimensions. Participants wishing to concentrate on other aspects of the challenge such as recycling and or applications do not have to adhere to the specifications listed. Future events may have additional requirements on the hardware for safety related purposes.

What can we use for recycled material to be extruded into 3-D Printing media?
Typical materials used for food packaging in space are described in this document; however, substitution of such materials is possible with any non-hazardous material alternative with proper MSDS documentation. All material selection and experimentation is the sole responsibility of the participant(s)/team. NASA or HELIOS Technology Challenge is not responsible for any material selections made by any participant(s) and/or teams.

Where do I sign up to participate?
Visit www.helioschallenge.org for more information.

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